REVEALING THE INTERPLAY BETWEEN SMBH AND STARBURST ACTIVITY IN THE BRIGHTEST FAR-IR GALAXY IN THE UNIVERSE

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INAF - OATS

Collaborators
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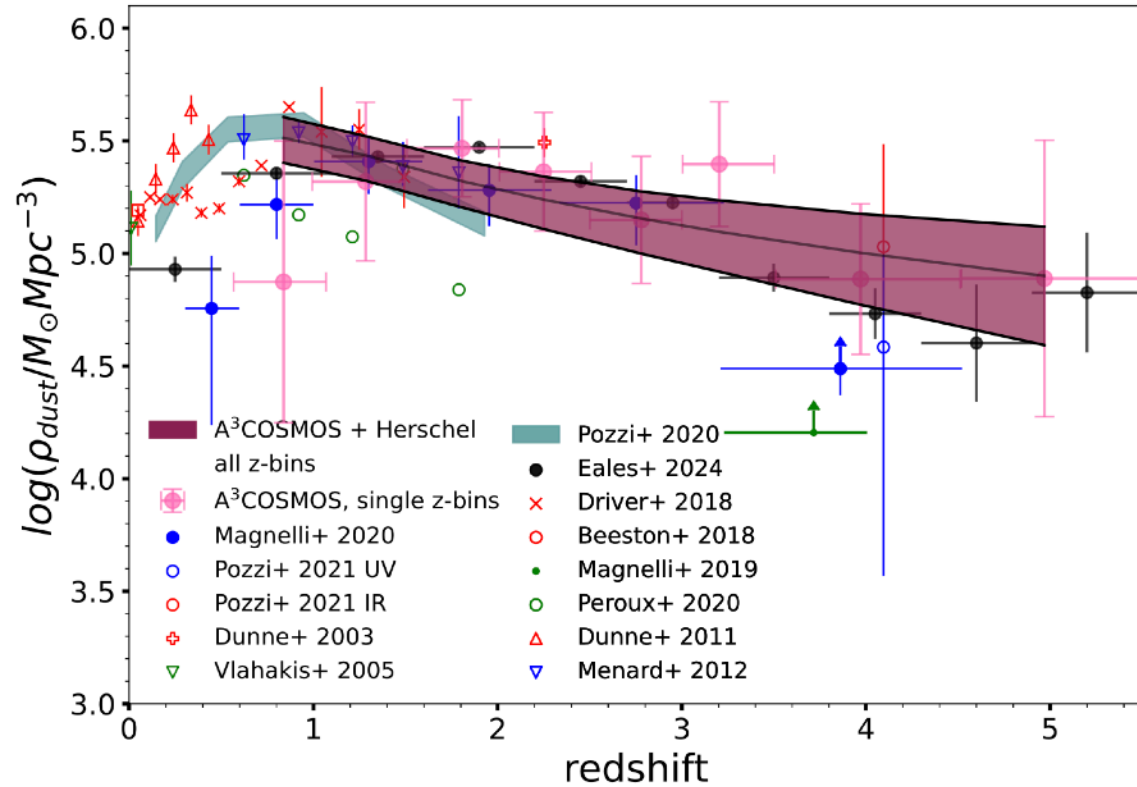F. Fiore - INAF OATs
S. Bianchi - INAF OAA
S. Gallerani - SNS
F. Di Mascia - SNS
P. Barai - INAF OATs

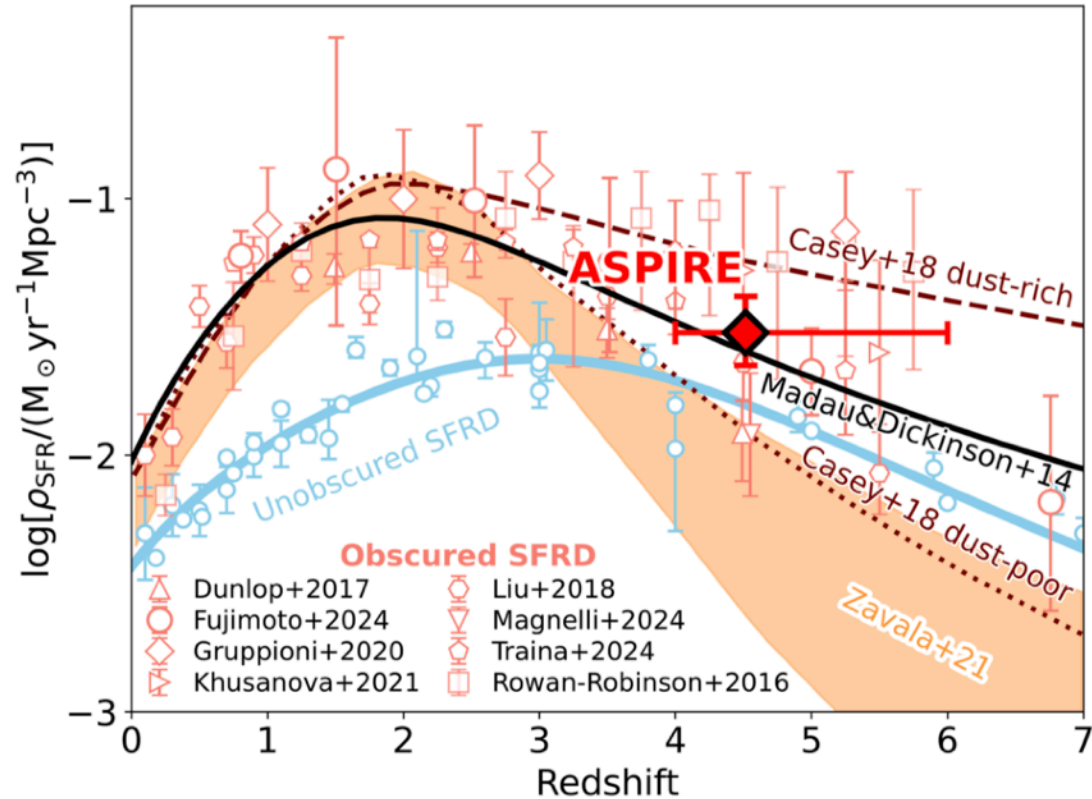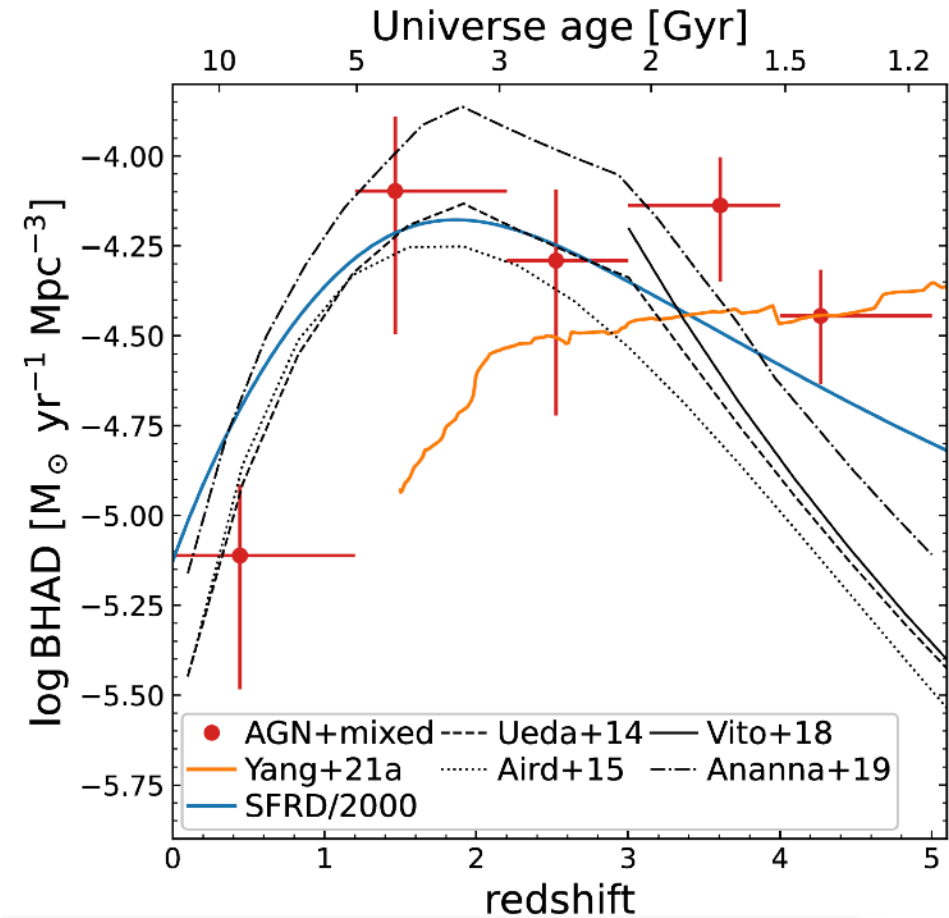# A DUSTY HIGH-Z UNIVERSE

Traina+2024

A DUSTY HIGH-Z UNIVERSE
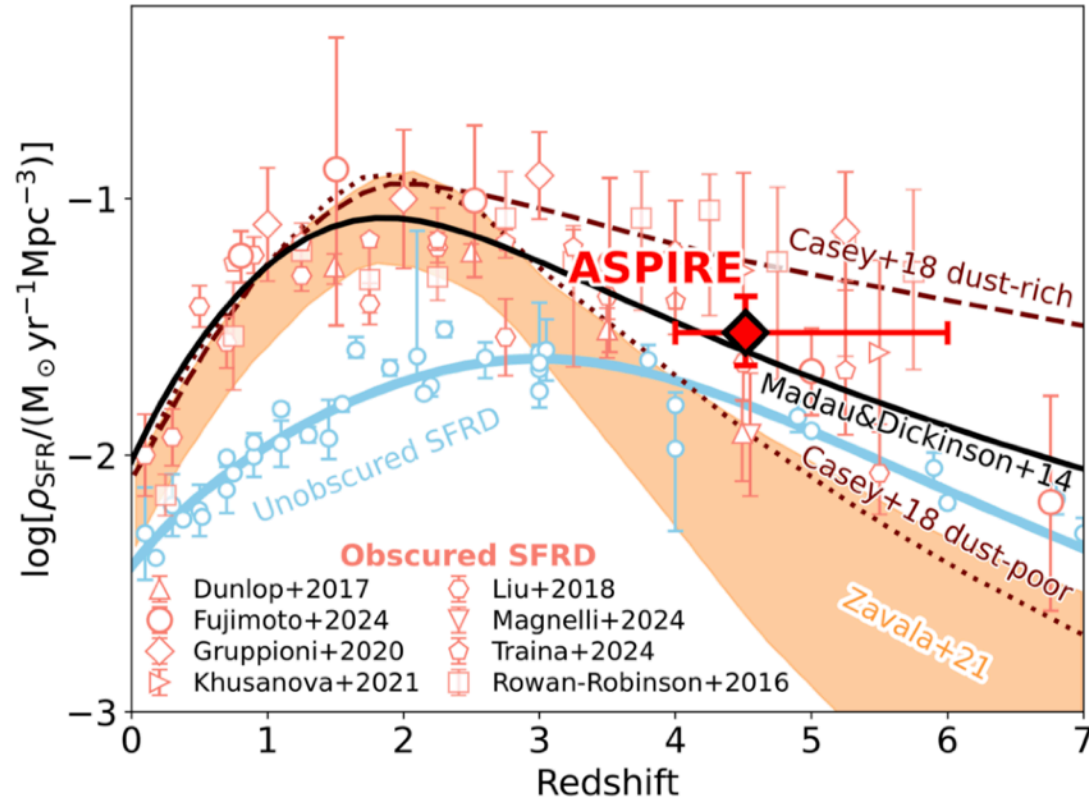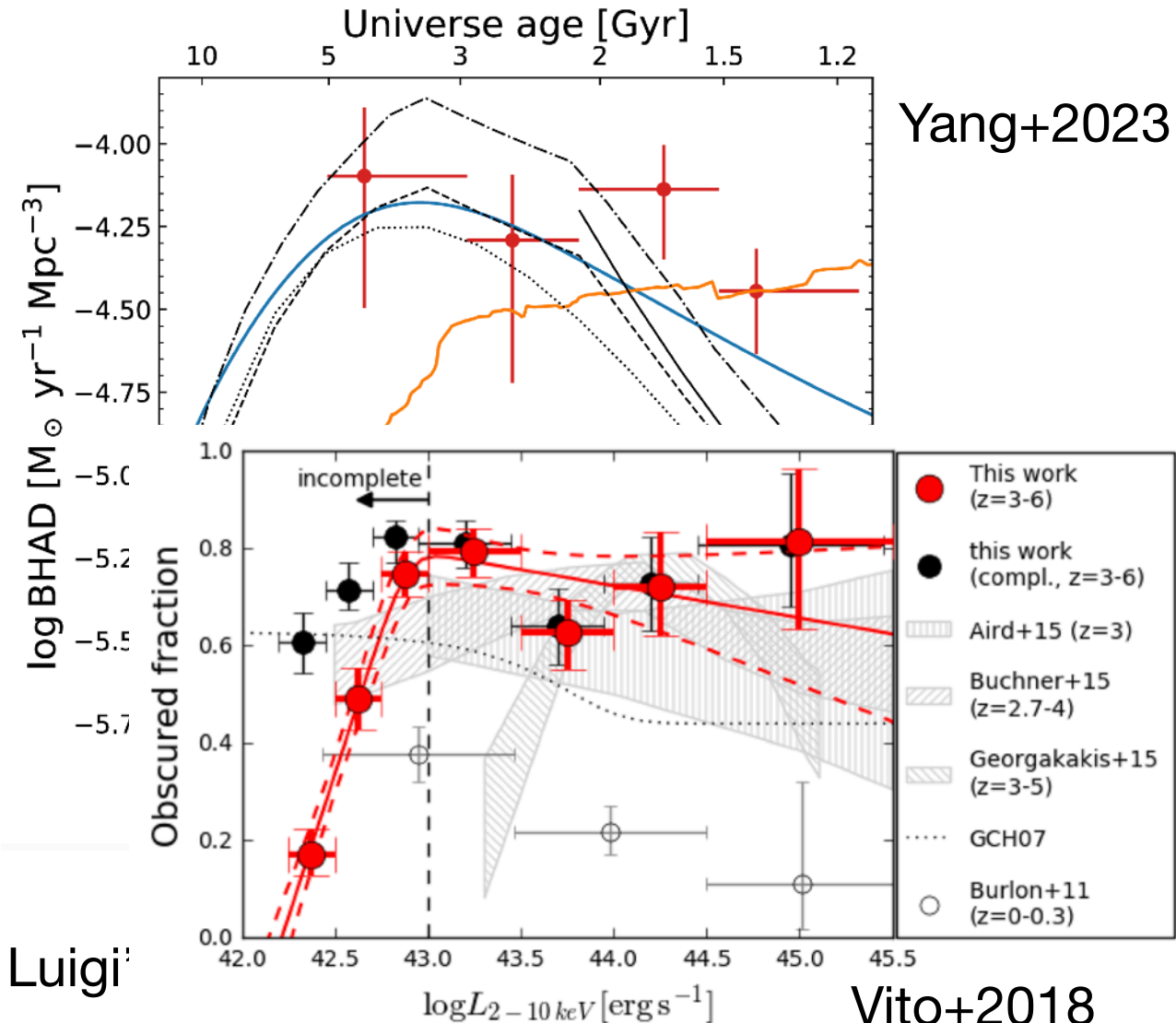

Sun+2025

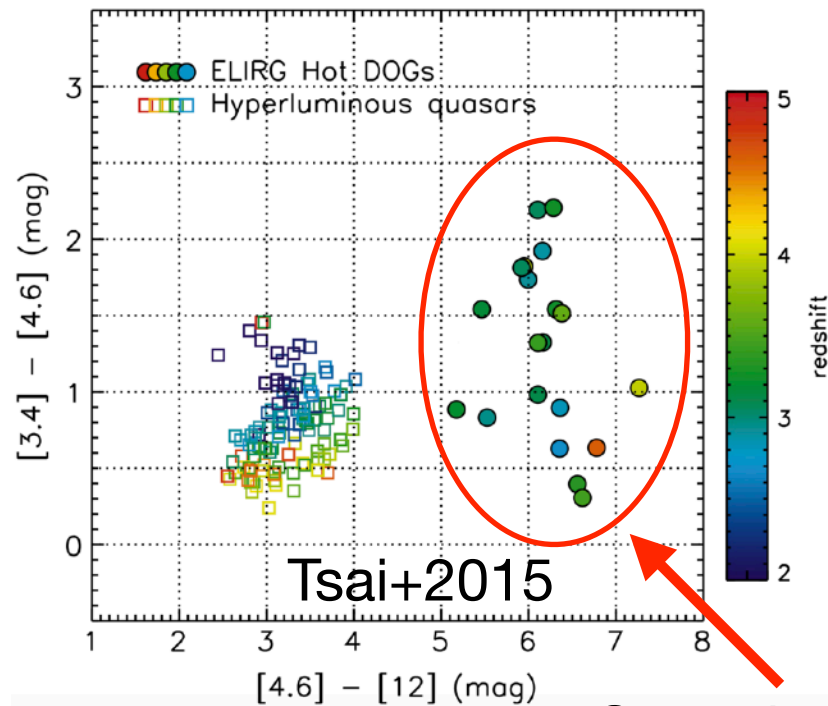Yang+2023

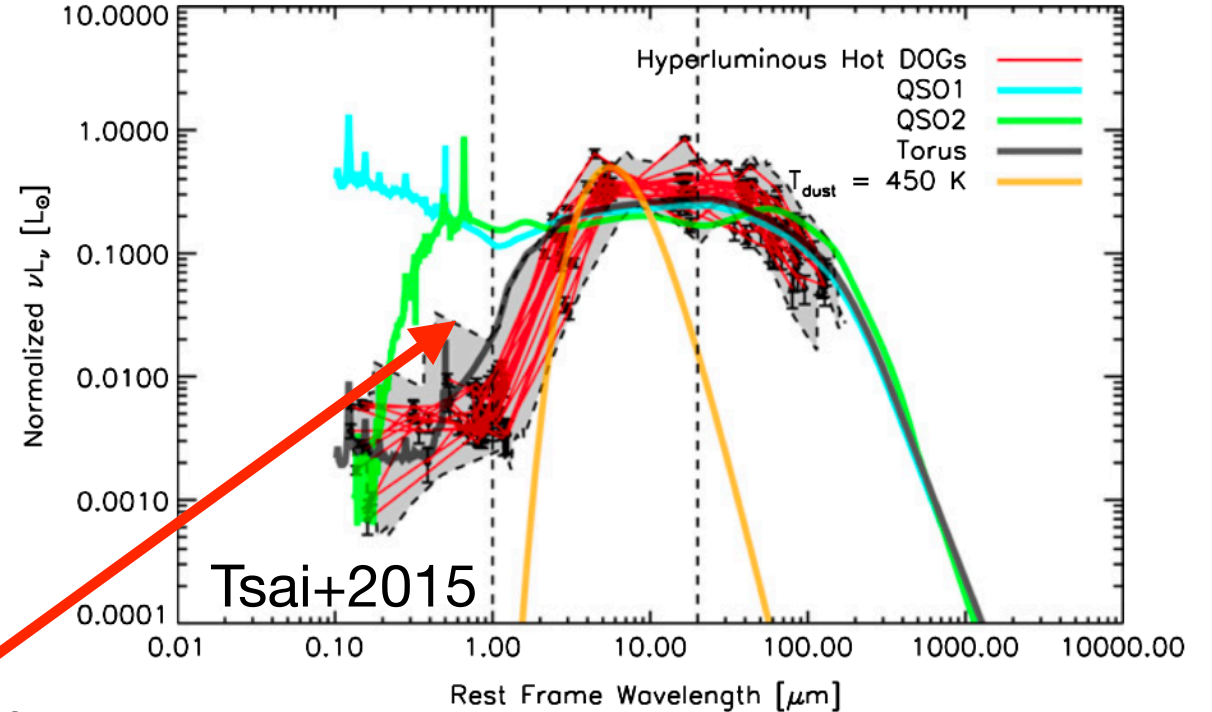See also Luigi's talk!

A DUSTY HIGH-Z UNIVERSE

Yang+2023

Sun+2025

See also Luigi

Vito+2018

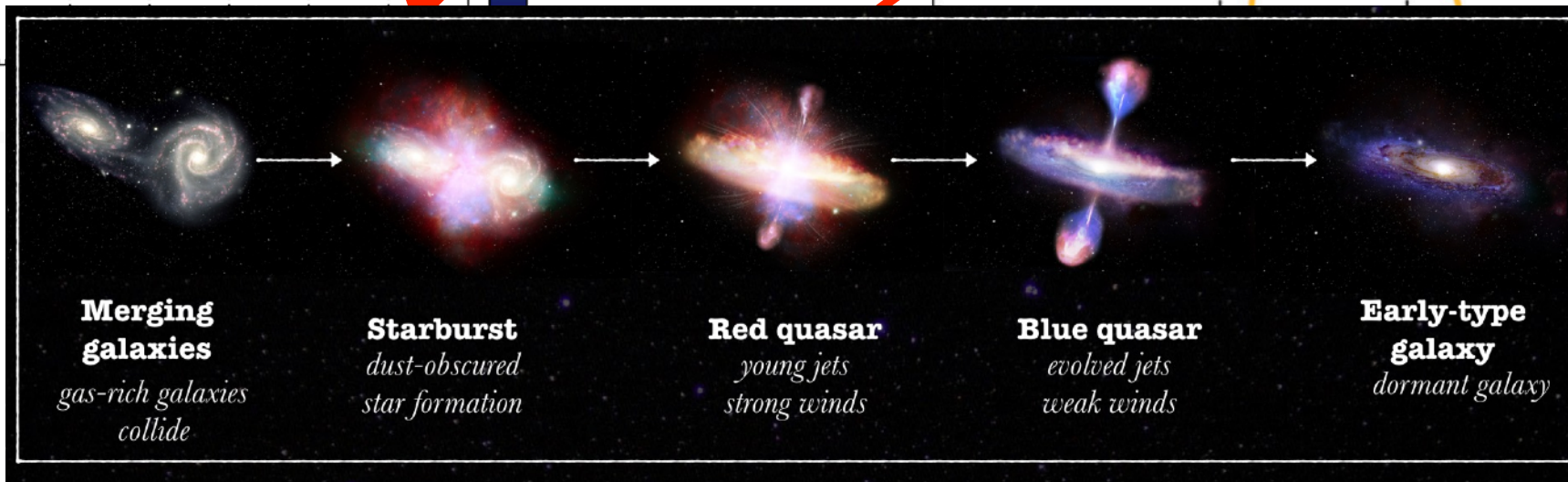# HOT DUST OBSCURED GALAXIES

Tsai+2015

Steep increase of the mid-IR flux

Tsai+2015

$$L_{IR} \sim L_{bol}$$

HOT DUST OBSCURED GALAXIES
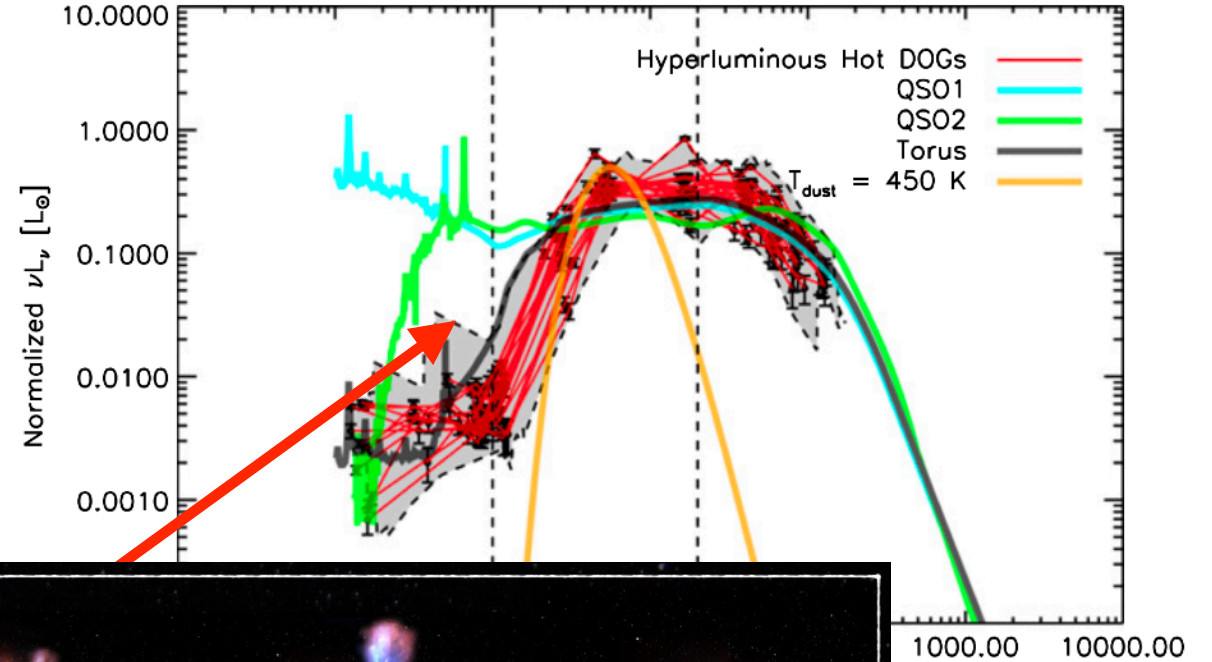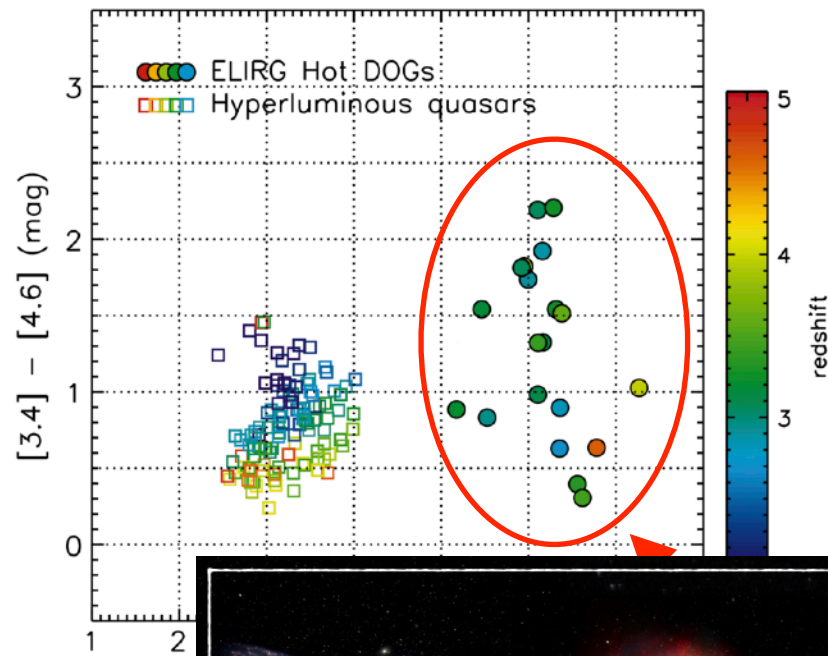
Credits: Gemini Obs.

W2246-0526: A CROWDED ENVIRONMENT

- **Diffuse dust emission** over several kpc, likely signature of past/ongoing mergers.

- **Mergers** play a key role in such dense environment, triggering both SFR and BH accretion.

- Evidence of a potential **multiphase outflow** (Bischetti+, in prep.).

- X-ray observations suggest a **deeply obscured SMBH** ($L_{2-10keV} < 10^{45}$ erg/s; Vito+2018).
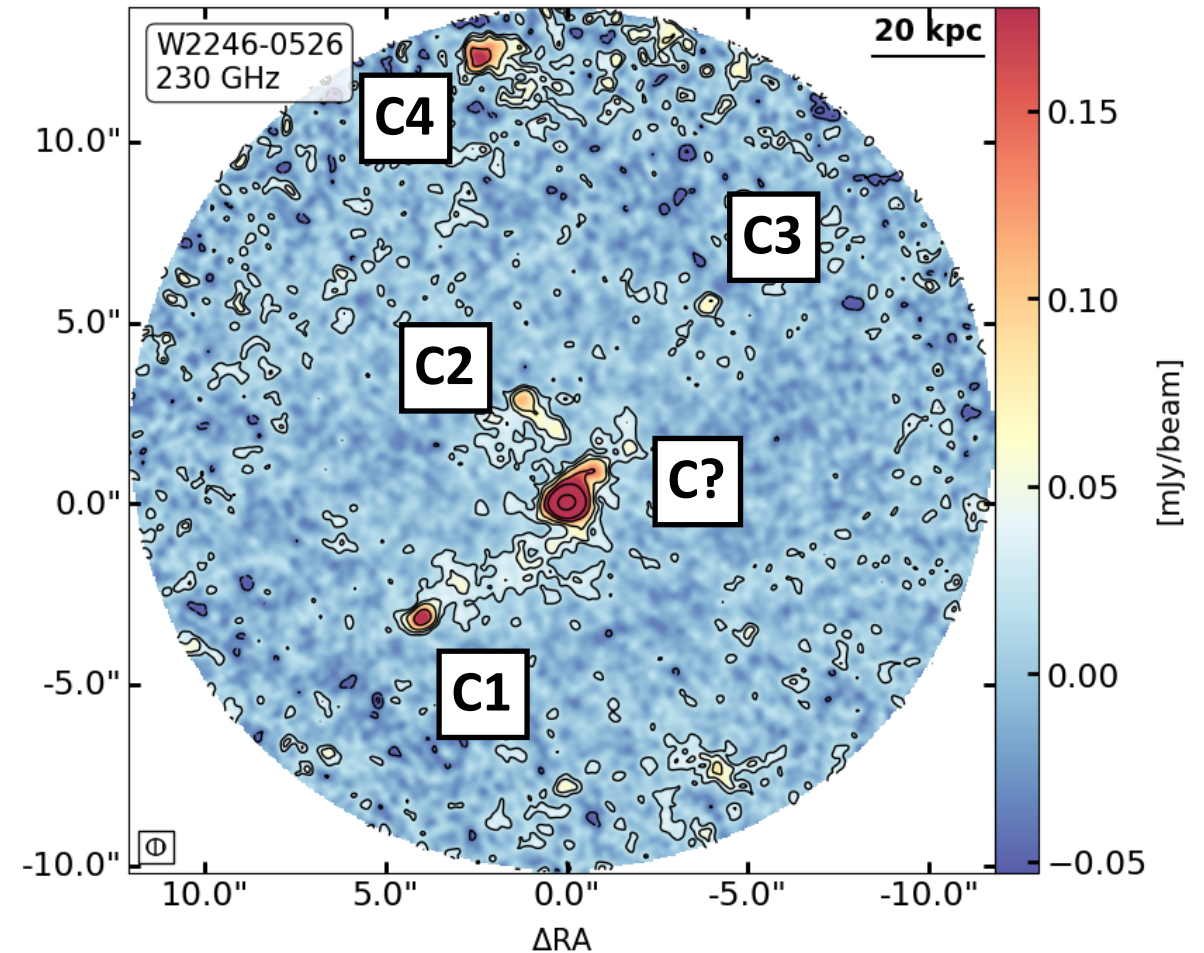
Salvestrini+ in prep.

THE INTERPLAY BETWEEN SMBH & SF

- Literature works already attempt to model the SED of this extremely IR-bright object:

  - Clear **dust temperature gradient**, up to 110K!

  - Continuous temperature model.

  - Stellar light ($M_\star \sim 10^{12}\ M_\odot$) emerges as the and AGN is deeply obscured.
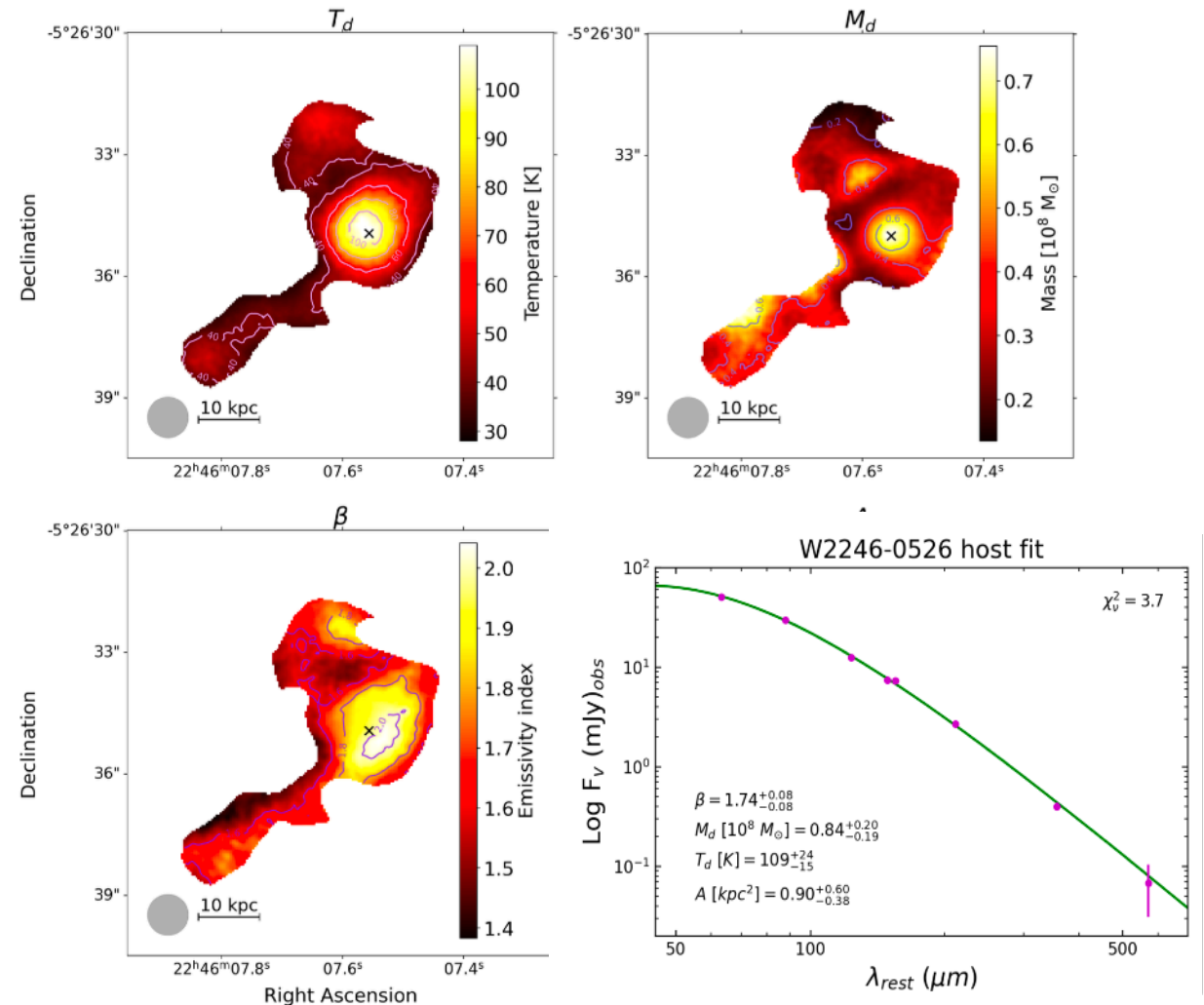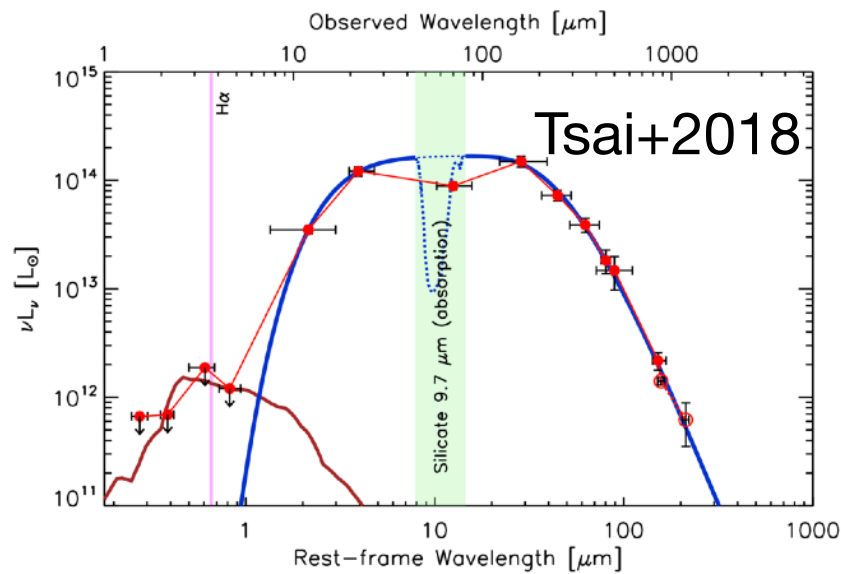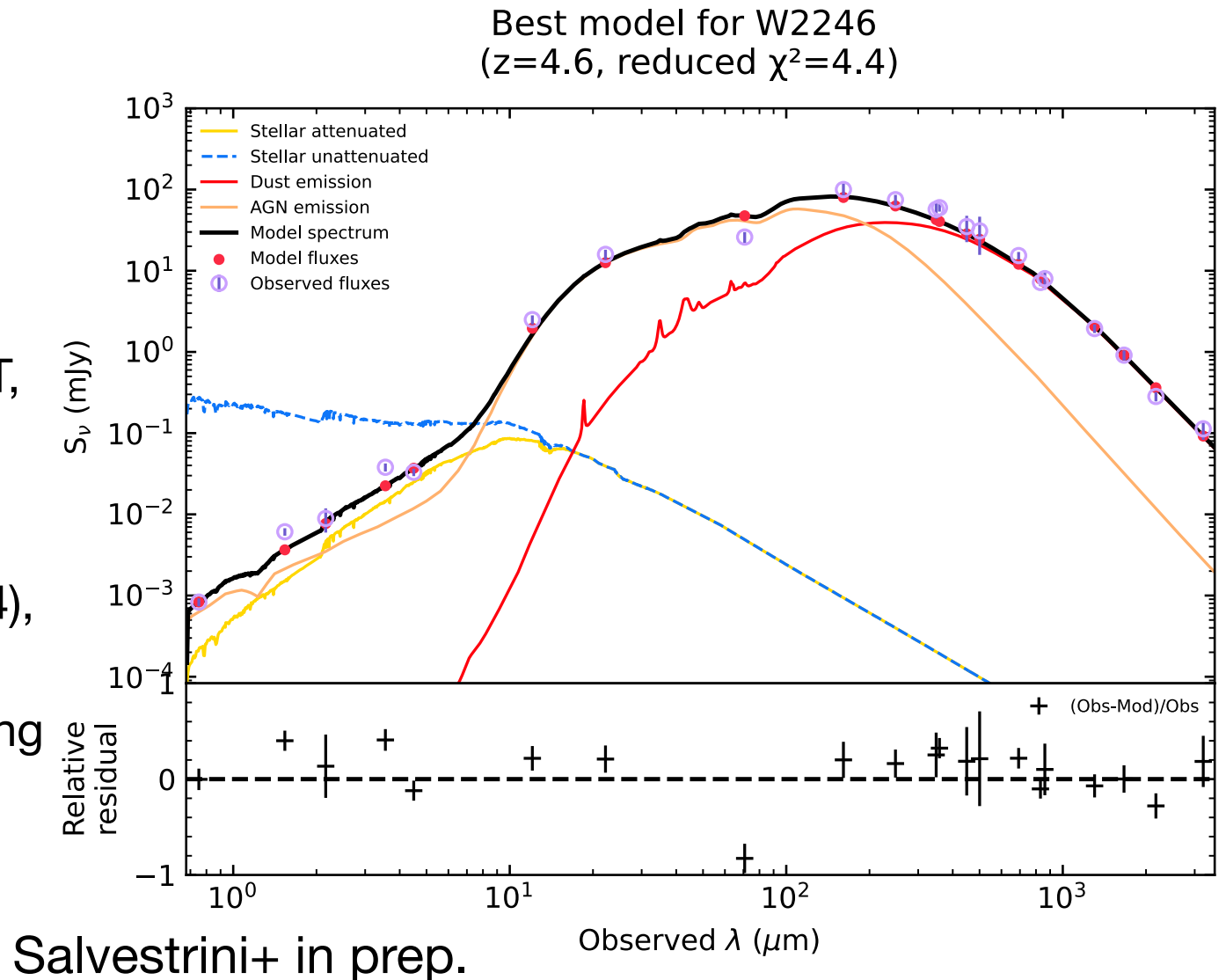
Tsai+2018

Fernández Aranda +2025

SED FITTING - CIGALE

WORK IN PROGRESS

- We collect observations from UV, HST, JWST NIRSpec, WISE, Spitzer, Herschel, SCUBA2, ALMA

- We tested several combination of libraries for SFH, dust (THEMIS, DL14), AGN (SKIRTOR, Fritz+06).

- The **AGN is deeply obscured**, allowing us to probe the stellar emission.

- **SFR**~7000-11000 Msun/yr ???

Best model for W2246
(z=4.6, reduced χ²=4.4)

Legend:
- Stellar attenuated
- Stellar unattenuated
- Dust emission
- AGN emission
- Model spectrum
- Model fluxes
- Observed fluxes

S_ν (mJy)

Relative residual

(Obs-Mod)/Obs

Observed λ (μm)

Salvestrini+ in prep.

CIGALE

RADIATIVE TRANSFER SIMULATIONS

WORK IN PROGRESS

- **Radiative transfer simulations** with *SKIRT* (Baes+2003).

- Based on the results by Di Mascia+2022 on z~6 quasars (see also Scheider+2015).

- **Assumptions**: SMC composition of dust; fixed dust-to-metal fraction; energy balance between the local radiation field and dust re-emission.

This is not a fit.
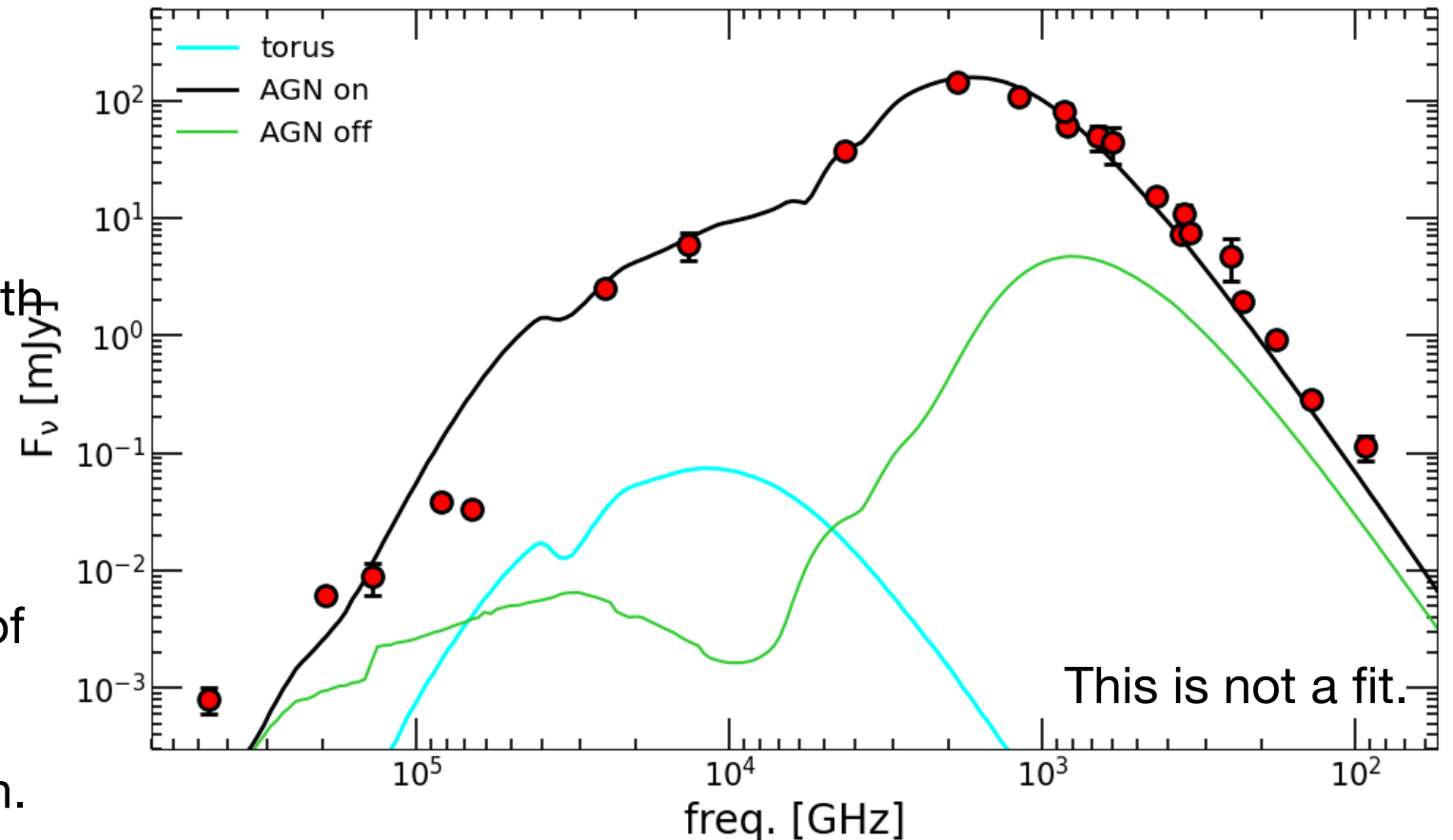
Salvestrini+ in prep.

WAITING FOR PRIMA

- We are using this target as a test-case for developing an approach based on radiative transfer modeling.

- **PRIMA** is complementary to both JWST and ALMA

- **PRIMA** will play a crucial role in exploring the co-evolution of SMBHs and their host galaxies at Cosmic Noon and beyond.
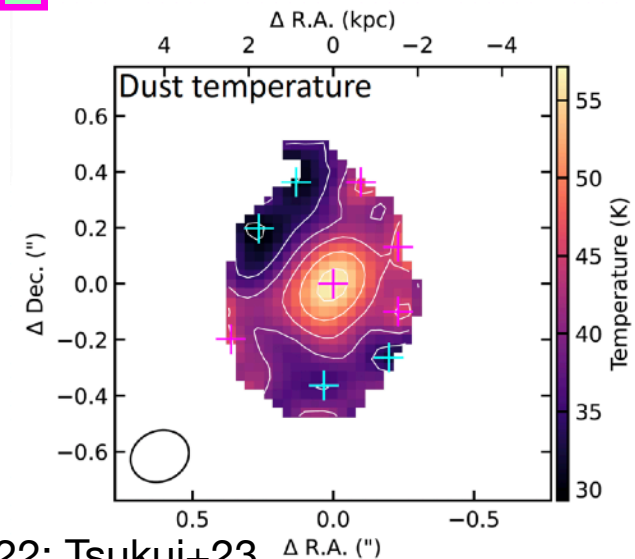
Best model for W2246
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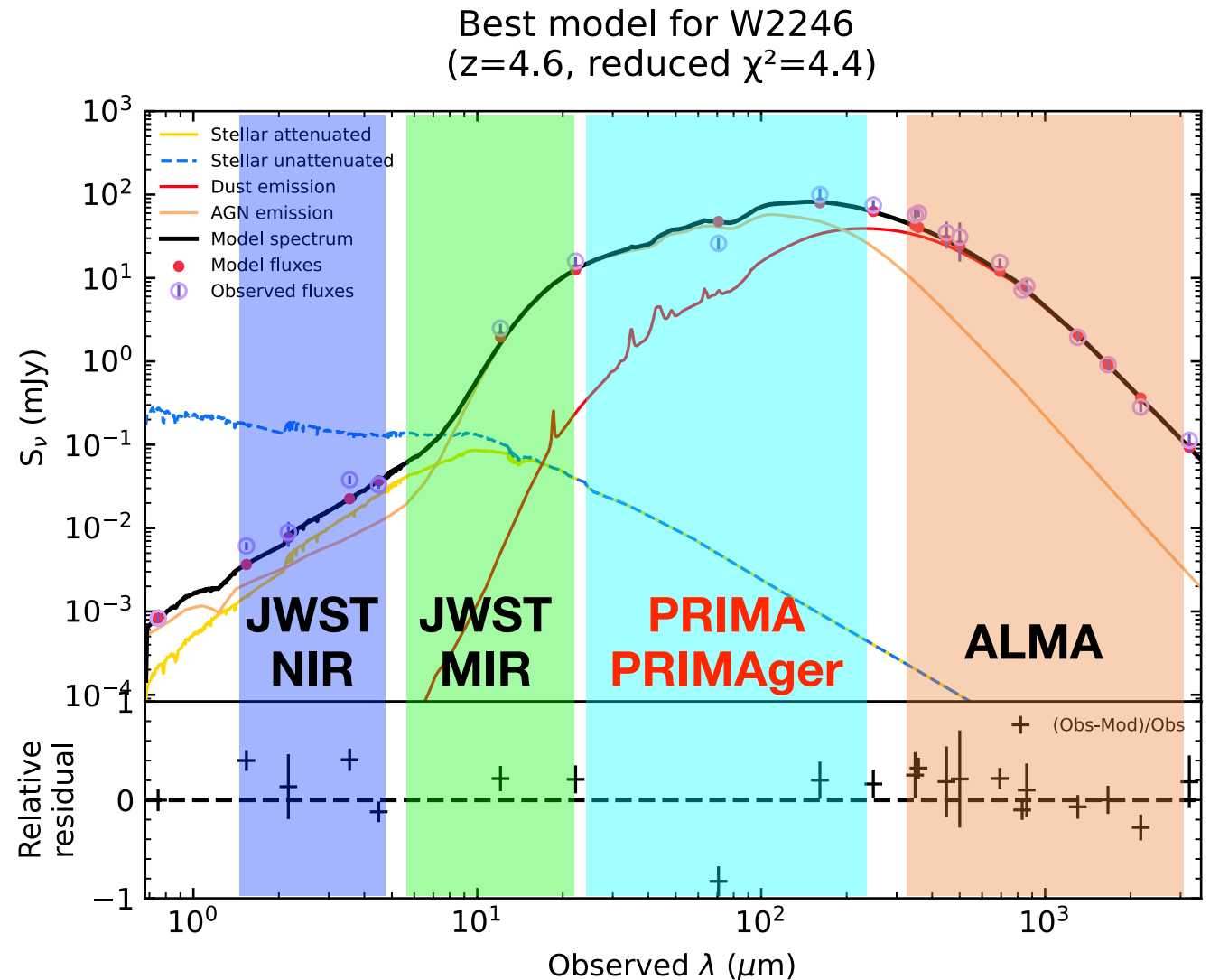
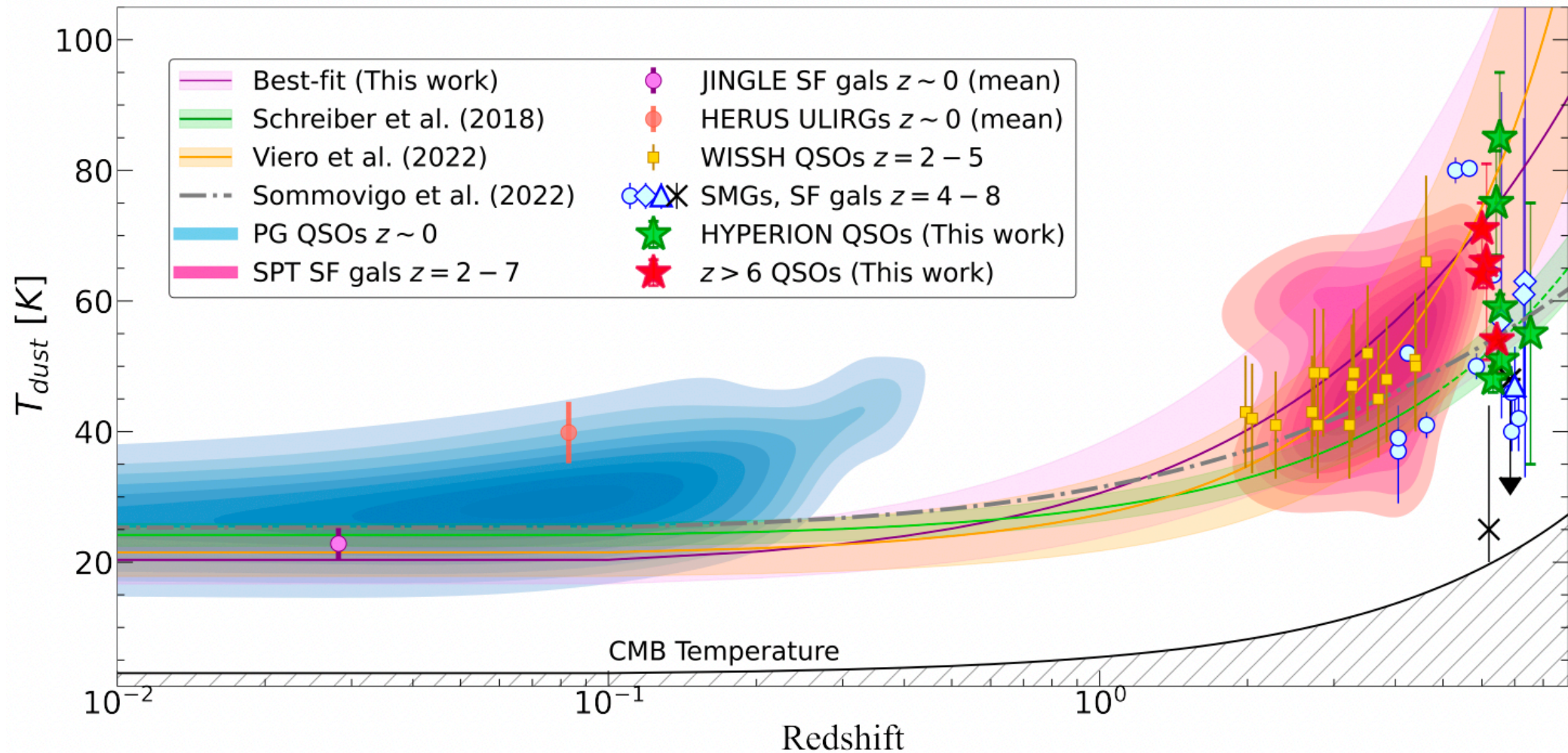# I) INCREASING THE STATISTICS WITH PRIMA

Schneider+2015
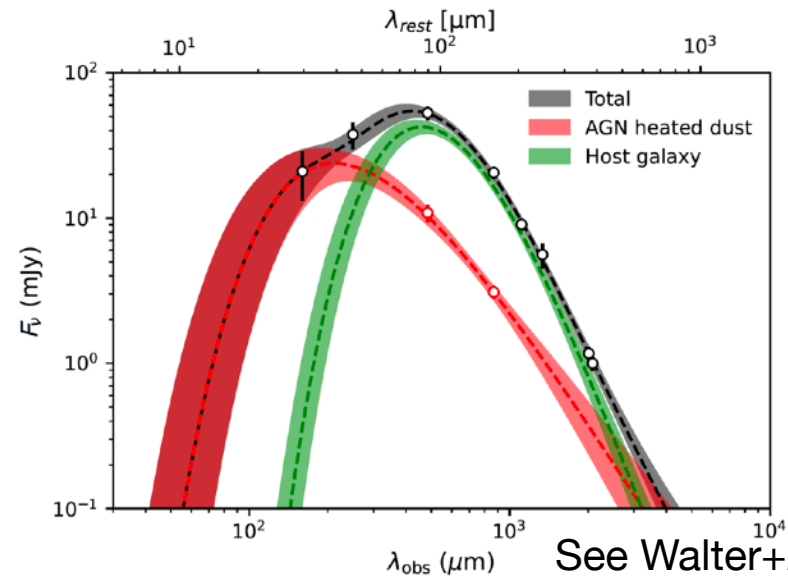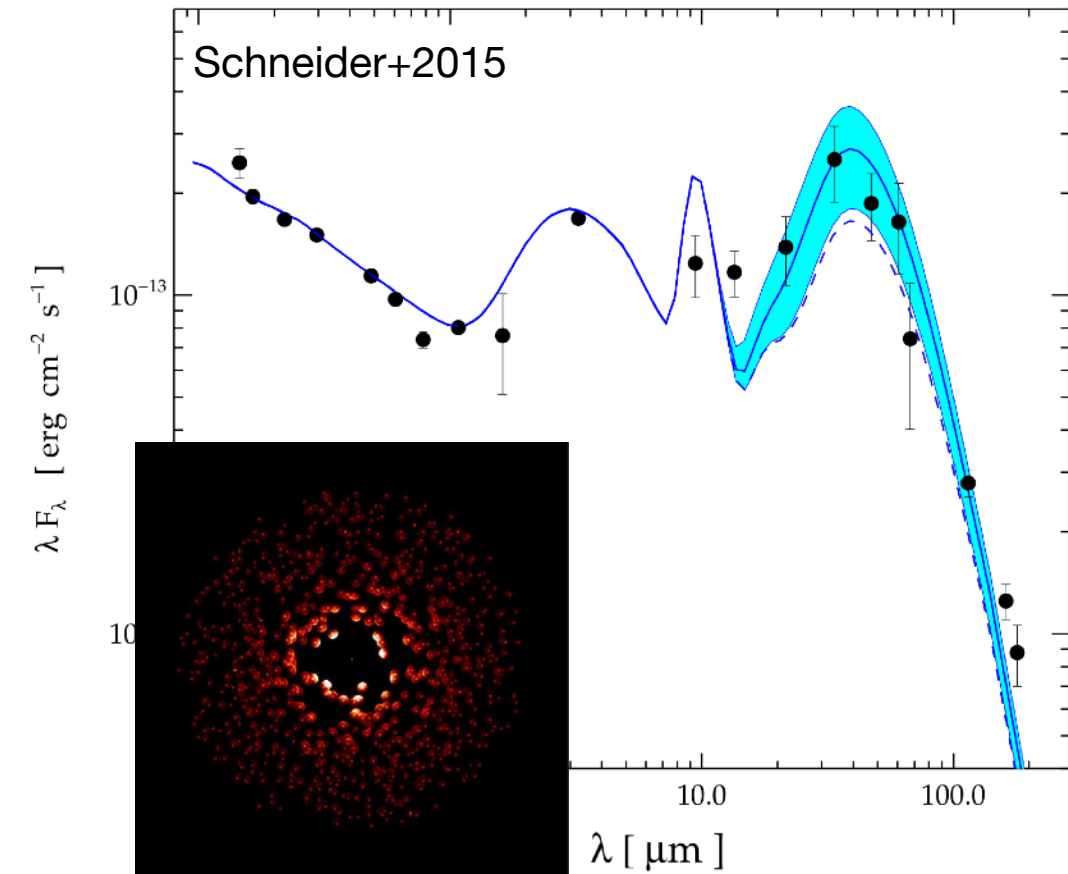
See Walter+22; Tsukui+23.

We are currently limited by the lack of a far-IR observations to explore the dust heating in luminous AGN/quasars at high-z.

REF: Tripodi, FS+24

See also the talk by Francesca Pozzi.

III) DUST PROPERTIES IN THE FIRST QUASARS

- Tripodi,FS+2025, Salvestrini+2025 studied the far-IR SED emission of quasars at the Epoch of Reionization observed with ALMA.

- We fit far-IR SED with a modified black body (***Eos-DustFit*** code ; Tripodi,FS+2024; Salvestrini+2025):

  - T_{dust} ~55 K (Tripodi, FS+24).

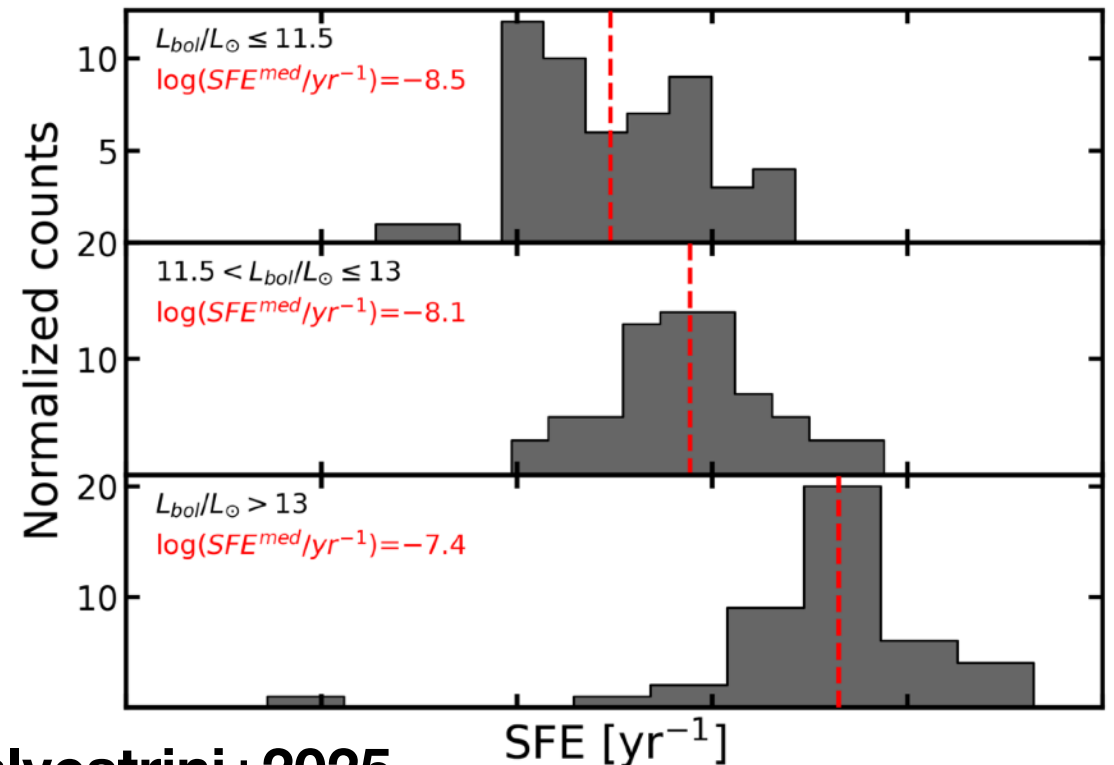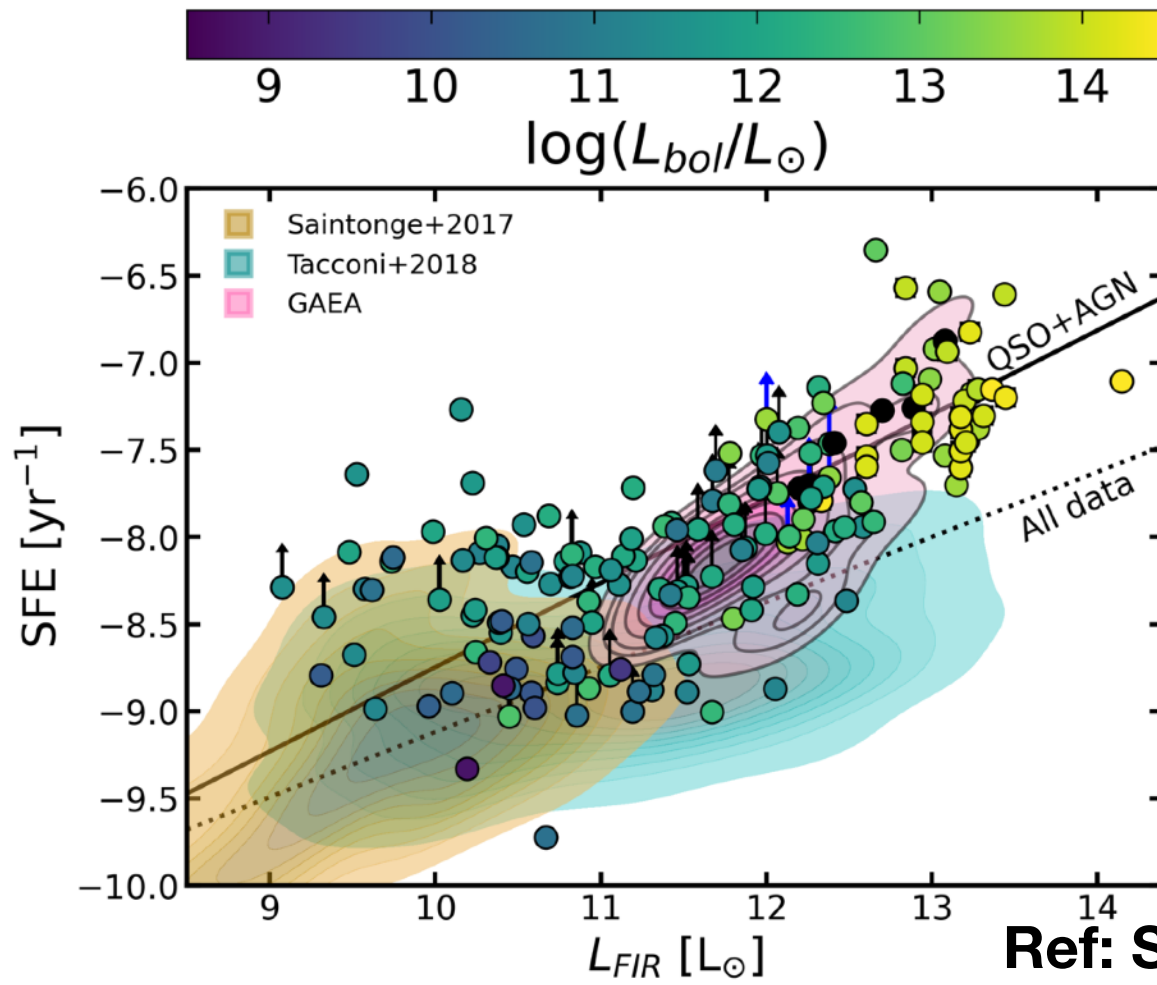 - SFR $\propto$ L_{FIR}, but ~50% of L_{FIR} due to dust heated by the QSO.
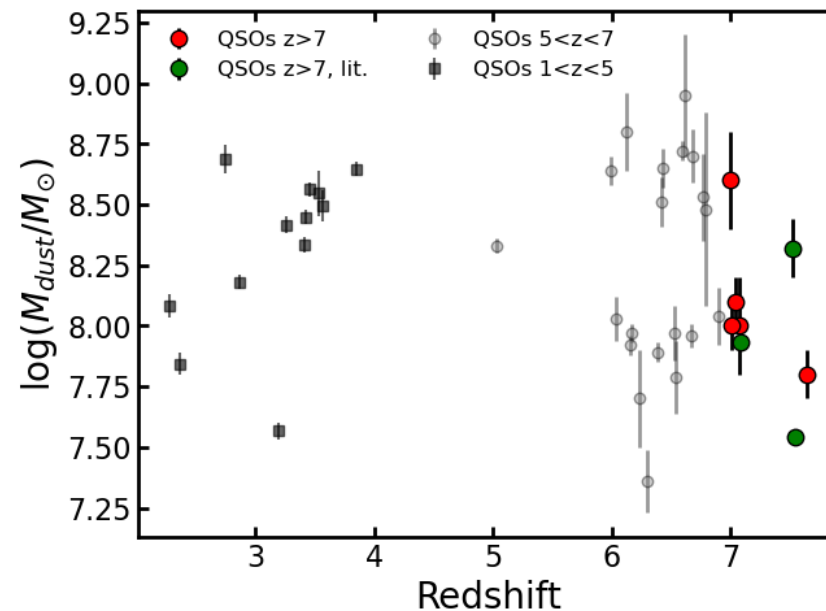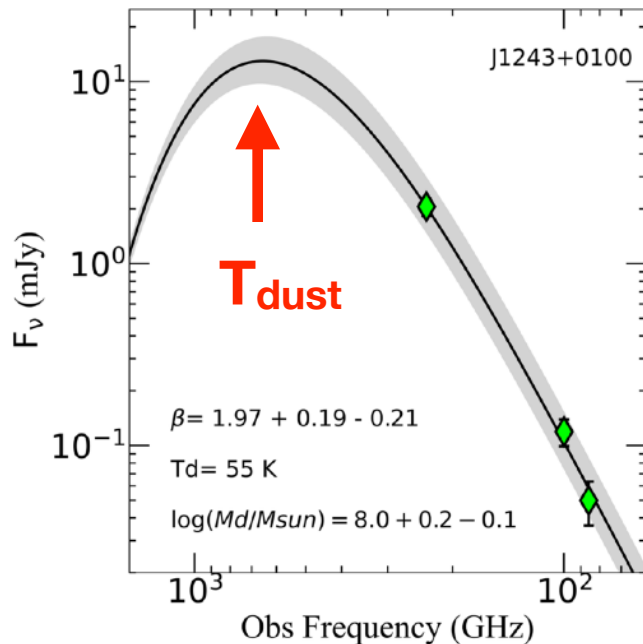
Ref: Salvestrini+2025
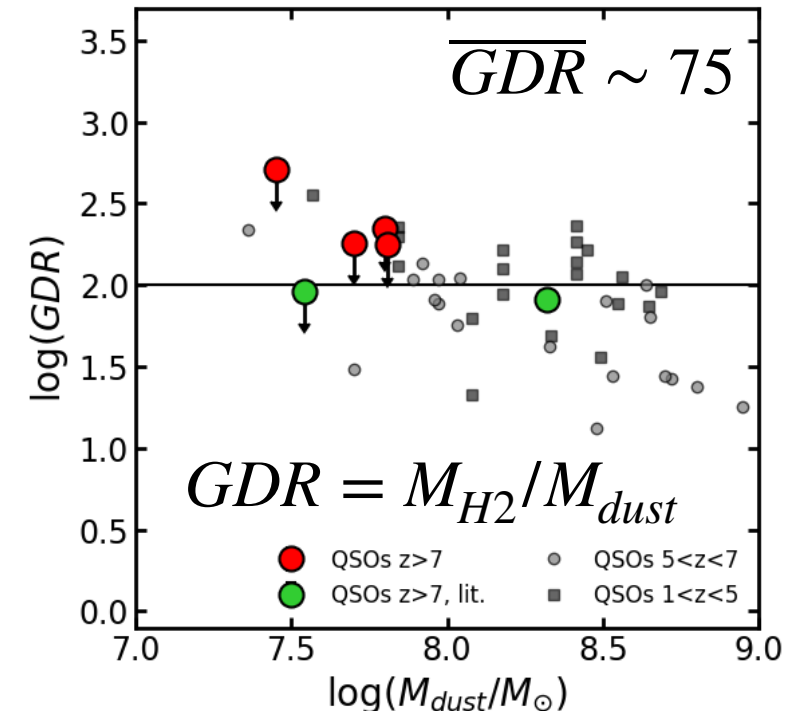
IV) SMBH & HOST GALAXY COEVOLUTION?

Irrespective of redshift, **SFE (SFR/M_{H2}) increases with L_{bol}**:

1) QSO triggers SF in the host.

2) Starburst phase favours QSO.

3) Delayed feedback.

Ref: Salvestrini+2025

CONCLUSIONS

- Hot DOGs may be a transient and obscured phase in the global evolution of quasars, making them particularly important. However, we are lacking of far-IR observations in a key regime to constrain the relative role of SMBH accretion and star formation (Salvestrini+, in prep.).

- We need **radiative transfer simulations** to properly account for dust heating due to the presence of AGN/quasars. This is key to derive accurate measurements of dust content, SFR, dust temperature (Salvestrini+2025, A&A, 695A, 23S).

- ALMA is crucial to probe the host galaxy's ISM in high-z quasars and JWST can reveal even the population of high-z AGN at lower-luminosity.
  PRIMA will be a game changer in investigating the complex mechanism of dust heating in AGN/quasars from Cosmic Noon and beyond.

- Several scientific questions will be investigated with **PRIMA.**